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Urbanization Process and Land Use Policy

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Abstract

Within a framework of NEG model, this paper intends to show that urbanization rate is determined as a synthetic result of rational behavior of each socio-economic agent. In particular, a model is constructed with bearing in mind to explain the urbanization process in China such that the role of government in managing land use is explicitly incorporated and policy effects can be evaluated. Some results of theoretical analysis and numerical simulation analysis are contrasted with the ones of Fujita-Krugman (1995) incorporating land into a NEG model as well.

Key Words: *Urbanization process, Rural –Urban migration, Land use policy, Transportation cost, NEG model.*

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By Xiangchun Lu and Komei Sasaki

1. Introduction

Urbanization is accompanied by shifts of labor force and land from the rural sector to the urban sector. In most developed countries, the urbanization process is completed while in many developing countries or regions this process is still under way. Statistics issued by the United Nation indicate that about 3 billion people in the world, namely 48% of the total population, come to live in urban areas up to 2003. Presently, the urbanization rate (measured by the share of population in the urban areas) is 75% in developed countries and 42% in developing countries.

Most studies, so far have treated urbanization statistically as “macro-economic” or an aggregated social phenomenon, with some exceptions such as Harris-Todaro model [6] where rural-urban migration is explained as the result of “micro-economic” rational behavior. Examples of the “macro-economic” approach include Sovani [11], Gilbert and Gugler [5] on the relation between industrial structure and urbanization level; Henderson [8] on urbanization and urban concentration; and Rosen and Reznich [10] and Wheaton and Shishido [12] on urban concentration and economic development. In most cases, urbanization rate (indicating the extent of urbanization) is measured by the share of urban population, but few attempts have been made to explain the variations in urbanization rate on the basis of behavioral analysis of socio-economic agents. Among the explanatory variables in the statistical regression models for urbanization rate are included per capita GDP, its squared value, and industrial composition rate of agriculture, manufacturing and services. However, some of these explanatory variables will be affected by urbanization rate itself. For example, agglomeration economies (diseconomies) might be generated as urbanization proceeds, and thereby per capita GDP is increased (decreased). Furthermore, values of some policy variables, such as transportation infrastructure level, will vary according to the level of urbanization. To sum up, statistical models for urbanization rate can explain “what has occurred with urbanization”, but cannot explain the causes of variations in urbanization rate.

One of the main conclusion in Becker, Mill and Williamson [1] which empirically analyzed the urban growth in detail in India is that the scarcity of agricultural land relative to rural population has been a strong push factor of rural-urban migration. This hypothesis is also supported by some demographic research (e.g., Williamson [13], and it is acceptable in the light of the observation that in most developing countries, personal income in the agricultural sector is directly influenced by arable land size relative to population.

Davis and Henderson [3] attempted to ascertain the effects on urbanization rate of national policies by the cross-sectional analysis of aggregated data from each country. For instance, polices to change the terms of trade will directly affect the industrial structure in a country, whereby, urbanization level is indirectly affected. However, their major conclusion is that the “direct” effect of policies is rather small. It is noted that a coefficient of national land area in their regression is negative since average transport cost is proportional to land area. This result suggests that improvement of the transportation system might promote urbanization in a country.

As described above, so far not many micro socio-economic theories on urbanization have been developed. Among the few theoretical works, Brueckner [2] made a simple but clear-cut analysis, interpreting the realized urbanization rate as the result of a general equilibrium in a monocentric city model. In that model, urban population, city size (i.e., distance to city boundary), and utility level of residents are endogenously determined. The theoretical analysis is followed by an empirical analysis with cross-section data on 24 developing countries. A methodological contribution of Brueckner [2] was to show that the equilibrium city size is represented by a homogeneous function of degree zero with respect to income, transportation cost and agricultural rent, where a resident’s utility function is specified in a Cobb-Douglas type. This method avoids the difficulty stemming from differences in currency unit across countries in such a way that rural-urban income ratio, transport cost-urban income ratio and agricultural rent-urban income ratio are used as explanatory variables in a statistical model. The results of the empirical analysis in Brueckner [2] show that only the variable as rural-urban income ratio contributes to explaining the variation in urbanization rate. The theoretical model in Bruechner [2] determines the urbanization rate in a representative metropolitan area in country, while the empirical analysis there is based on aggregated values at the country level. Apart from this consistency, a drawback of Brueckner's model is that a shift of land from agricultural to urban use is not considered, with the assumption that land for urban use is unlimitedly available. Thus, the effect of land use polices on urbanization rate cannot be analyzed within that framework.

The New Economic Geography model (hereafter abbreviated to NEG model), which have attracted much attentions, explains the concentration level of economic activities and the distribution of city size. In the NEG model, however, the labor force in the agricultural sector is fixed, not allowed to move between sectors and, in addition, the factor of land, essential in the urbanization process, is not considered at all. As urbanization proceeds, more land is used for production of goods and services and above all, more residential land is necessary for migrants in a city. Kelly and Williamson [9] also emphasized that the housing market in the urban area affects rural-urban migration decision to a large extent and thus plays an essential role in the analysis of the urbanization process. In fact, scarcity of land in a city raises the housing rent and thereby the living cost in a city, retarding in-migration to a city (Kelly and Williamson 1984, pp. 96-97).

It is the work by Helpman [7] that treated the land factor earnestly within the framework of a core-periphery model. Instead of immobile "farmers", fixed amount of land for residence works as a centrifugal factor. Land is publicly owned such that rental revenue in all the regions is equally distributed among people. Each person resides in one region and works for the manufacturing sector producing variety-good in that region, whose utility level depends on the consumption of variety-good and the size of the residence. Equilibrium of this system (i.e., equalization of utility level among people) is characterized by "dispersion" of economic activities when the elasticity of substitution between varieties and/or the expenditure ratio for housing is vary large; and by "agglomeration" when they are vary small. In a striking contrast to the Krugman type core-periphery model, a decrease in transport cost will lead not to "agglomeration". This is due to the introduction of (immobile) land which is essential to residents; people might prefer to reside in a region with lower land rent even if they must incur higher transport cost.

Fujita and Krugman [4] also developed a NEG model with land incorporated. Land was, however, used only for agricultural production and thus the area of a region was determined by output (or employment) in agricultural sector. Unlike the Krugman type {Krugman, 1991 50 /id}model, the model explicitly considered the transport costs of agricultural products as well. In this situation, the complete agglomeration equilibrium (where the manufacturing sector concentrates only at the center) emerges where the transport costs of agricultural products are not so large relative to that of manufacturing product. Conversely, locations of manufacturing industry will be dispersed from the center when the transport cost of manufacturing goods becomes relatively lower.

Within a framework of the NEG model, but with a model different from the typical NEG models, the present paper intends to show that urbanization rate in a region is determined as a synthetic result of the rational behavior of each agent. In particular, a model is constructed with bearing in mind to explain the urbanization process in China such that the role of government in managing land use is explicitly incorporated and policy effects can be evaluated. In China, urbanization has proceeded abruptly after the economic reform of 1978; the urbanization rate (in terms of the share of urban population) has doubled for the twenty-two years from 17.92% to 36.22% in 2000. The mean annual increase rate in the urbanization was 3.79%. The annual population growth rate during this period in China was 1.29%, which implied that the urban population has increased at an annual rate exceeding 5%. In some provinces, the restriction on rural-urban migration, called "Hu Kou", was removed which is expected to further accelerate the urbanization process.

The present paper attempts to prepare a theoretical framework for evaluating the effects on urbanization of land use and public investment policies in China. The structure of the paper is as follows. In section 2, the economic behavior of each agent is explained and the regional system is modeled. In section 3, market equilibrium of the system is analyzed and the urbanization process is examined. In section 4, optimal land use policy is introduced. In section 5, comparative static are performed by numerical simulation analysis. In section 6, our model is compared with that of Fujita and Krugman [4], and in section 7, the main result s of the analysis are summarized.

2. The model

Let us suppose a region consists of two districts: urban and rural. Total land area in a region, *D*, is fixed and all land is owned by the regional government. The regional government will strategically divide the total land for alternative uses: the area of land in urban and rural districts is determined, and then the land area in each district is divided into alternative uses, for production and residence. To sum up the following relation holds for land area:

$$\begin{aligned} D_U + D_A &= D \\ D_{Up} + D_{Uh} &= D_U \\ D_{Ap} + D_{Ah} &= D_A \end{aligned} \tag{1}$$

in which the subscripts U and A represent “urban” and “rural” sectors, respectively, and p and h denote “production” and “residence”, respectively.

Depending on the skill level, the workers (=population) in this region is classified into high-skill labor and low-skill labor. It is assumed that high-skill labor lives only in the urban district while low-skill labor is mobile between the urban and rural districts and some are employed in the manufacturing industry and others work in the agricultural sector.

2.1. Production Sector

Two production sectors are operated in the urban district; manufacturing industry and intermediate-good industry. Manufacturing industry produces homogenous output using intermediate goods as inputs. The production function of a representative manufacturing firm is specified as follows.

$$q_M = G_M l_M^{\alpha} \Phi(s)^{\beta} d_M^{1-\alpha-\beta} \qquad (2)$$

Where q_M=output of manufacturing goods, l_M=low-skill labor input, and d_M=land area for production. G_M is the public capital stock of the infrastructure for production activity in the urban district (such as electricity, water supply and transportation), working to advance the technological level of all the manufacturing firms.

It is supposed that each individual firm in the intermediate good industry produces output slightly different from other firms' products, and an individual manufacturing employs a "variety" of differentiated intermediate goods. Φ(s) in (2) represents the aggregate intermediate good-input, specified in the following CES-type function.

$$\Phi(s) = (\sum_{i=1}^{n} s_i^{\sigma})^{1/\sigma} \qquad (0 < \sigma < 1) \qquad (3)$$

where s_i is the quantity of the i-th intermediate good. Intermediate good firms produce "different" products among them, and each manufacturing firm purchases products from every intermediate good firm. Φ(s) is, therefore, the index of combined inputs[1]. In (3), the elasticity of substitution between two different intermediate goods is calculated as 1/(1-σ), and a smaller σ provides a larger profit from a variety of intermediate goods.

It is supposed that an intermediate good firm employs only high-skill labor, and its production technology is represented by the identical production function in the following form.

$$x = \frac{1}{b} l_H - \frac{a}{b} \qquad (a, b > 0) \qquad (4)$$

in which x=output of intermediate good, and l_H=amount of high-skill labor input. Since products are differentiated from each other and they can be substituted for each other as inputs into manufacturing production, every firm in the intermediate good industry faces a monopolistic competitive market. Therefore, in a long-run

[1] "Intermediate good" produced by high-skill labor is interpreted here as a kind of "service for business", including R&D activity.

equilibrium, the profit of any firm in this industry is zero where the price of intermediate good (p_s) and the output (x) are common to n firms. They are

$$p_s = \frac{bw_H}{\sigma} \tag{5}$$

$$x = \frac{a\sigma}{b(1-\sigma)} \tag{6}$$

and the number of firms (=number of types of intermediate good), n, is determined as

$$n = \frac{L_H(1-\sigma)}{a} \tag{7}$$

where w_H=wage rate of high-skill labor, and L_H=population of high-skill labor.

On the other hand, the market of manufacturing good is assumed to be perfectly competitive. Letting p_M denotes the price of manufacturing good and w_M the wage rate of low-skill labor in the urban district, under the constant return to scale in the production function of (2), profit-maximizing labor input per land area and each intermediate good input per land area, respectively, are derived as follows:

$$\bar{l}_M = \frac{l_M}{d_M} = \left(\frac{\alpha^{1-\beta} \beta^{\beta} G_M p_M}{w_M^{1-\beta} \tilde{p}_s^{\beta}} \right)^{\frac{1}{1-\alpha-\beta}} \tag{8}$$

$$\bar{s} = \frac{s}{d_M} = \left(\frac{\alpha^{\alpha} \beta^{1-\alpha} G_M p_M}{w_M^{\alpha} \tilde{p}_s^{1-\alpha}} \right)^{\frac{1}{1-\alpha-\beta}} n_s^{-1/\sigma} \tag{9}$$

The quantity of intermediate good as input is the same among n varieties since their price is the same. Thus it follows that $\Phi(s)=n^{1/\sigma}s$. $\tilde{p}_s$ in (9) is aggregate price index of n intermediate goods, which is represented by

$$\tilde{p}_s = n^{\frac{1}{1-\frac{1}{1-\sigma}}} p_s = n^{-\frac{1-\sigma}{\sigma}} p_s \tag{10}$$

Because of the linear homogeneity of the production function, neither the size of each firm nor the number of firms is determinate, but the total output supplied by the manufacturing industry as a whole is calculated as

$$Q_M = G_M \bar{l}_M^{\alpha} (\bar{s} \cdot n^{1/\sigma})^{\beta} D_{Up} \tag{11}$$

We now turn to the agricultural sector. An agricultural firm employs low-skill labor and farmland as inputs, and its production function is specified in the form of

$$q_A = G_A l_A^{\gamma} d_A^{\ 1-\gamma} \tag{12}$$

where q_A=output of agricultural product, l_A=low-skill labor input, d_A=area of agricultural land, and G_A=public capital stock for agricultural production. In the perfectly competitive market, the total supply by the agricultural sector is

$$Q_A = G_A \bar{l}_A^{\ \gamma} D_{Ap} \tag{13}$$

where $\bar{l}_A$ =profit-maximizing low-skill labor input per farmland area, represented by

$$\bar{l}_A = \frac{l_A}{d_A} = \left[\frac{\gamma G_A p_A}{w_A}\right]^{\frac{1}{1-\gamma}} \tag{14}$$

in which p_A=price of agricultural product, and w_A=wage rate of low-skill labor in the rural district.

2.2. The Household Sector

Throughout the present paper, people are assumed to have identical preferences regardless of their skill level of labor. Their utility level depends on the amenity in their own residential district as well as the consumption of manufacturing good and agricultural product. The amenity level is determined by the public capital stock for life installed by the government such as schools, hospitals and parks. For example, the utility level of an individual residing in the urban district is illustrated as follows.

$$U_i = I_M c_i^{\psi} a_i^{\varphi} h_i^{1-\psi-\varphi} \tag{15}$$

$$i = M\,(low\text{-}skill\ \ labor),\, H\,(high\text{-}skill\ \ labor)$$

in which I_M=public capital stock improving the living environment, c=consumption of manufacturing goods, a=consumption of agricultural product, and h=residential land area. The budget constraint of a household is given by

$$(1-t)w_i = p_M c_i + \frac{p_A}{\tau_A} a_i + r_{Uh} h_i \tag{16}$$

in which the transport cost of agricultural product from the rural to the urban district is measured by τ_A ($0<\tau_A \le 1$), whereby an "iceberg" type transport cost is used rather than introducing a transport sector so as to simplify the model[2]. In (16), t denotes the income tax rate, p_M the *f.o.b.* price of manufacturing good, and r_{Uh} the land rent of residence in the urban district. Maximizing utility level subject to budget constraint gives:

$$
\begin{aligned}
c_i &= \frac{\psi(1-t)w_M}{p_M} \\
a_i &= \frac{\varphi(1-t)w_M \tau_A}{p_A} \\
h_i &= \frac{\left(1-\psi-\varphi\right)(1-t)w_M}{r_{Uh}}
\end{aligned}
\tag{17}
$$

The utility level of low-skill labor residing in the rural district is represented as

$$U_A = I_A c_A^{\psi} a_A^{\varphi} h_A^{1-\psi-\varphi}$$

where I_A is the public capital stock affecting the amenity level in the rural district. Each demand function is derived as

$$
\begin{aligned}
c_A &= \frac{\psi(1-t)w_A \tau_M}{p_M} \\
a_A &= \frac{\varphi(1-t)w_A}{p_A} \\
h_A &= \frac{\left(1-\psi-\varphi\right)(1-t)w_A}{r_{Ah}}
\end{aligned}
\tag{18}
$$

where τ_M represents the cost of transporting manufacturing good from the urban to rural district, and r_A is the land rent of residence in the rural district.

2.3. Market Equilibrium

The goods market:

From (6) and (9), the market equilibrium condition for intermediate goods is given by

$$D_{Up}\overline{s} = D_{Up}\left(\frac{\alpha^{\alpha}\beta^{1-\alpha}G_M p_M}{w_M^{\alpha}\tilde{p}_s^{1-\alpha}}\right)^{\frac{1}{1-\alpha-\beta}} n_s^{-1/\sigma} = \frac{a\sigma}{b(1-\sigma)}$$

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[2] It is hypothesized that the transport nodes are located at the center of each district, and that transport cost is generated between those nodes.

Which can be transformed into

$$\tilde{p}_s = \left[\frac{(1-\sigma)b}{a\sigma n^{1/\sigma}} D_{Up} \right]^{\frac{1-\alpha-\beta}{1-\alpha}} \left(\frac{\alpha^{\alpha} \beta^{1-\alpha} p_M G_M}{w_M^{\alpha}} \right)^{\frac{1}{1-\alpha}} \tag{19}$$

Using (5), (7) and (19), the wage rate of high-skill labor is expressed as follows.

$$w_H = \left(\alpha^{\alpha} \beta^{1-\beta} \right)^{\frac{1}{1-\alpha}} \left(\frac{(1-\sigma)^{1/\sigma} \sigma}{a^{1/\sigma} b} \right)^{\frac{\beta}{1-\alpha}} \left(\frac{p_M G_M D_{Up}^{1-\alpha-\beta}}{w_M^{\alpha}} \right)^{\frac{1}{1-\alpha}} L_H^{\frac{-\sigma(1-\alpha-\beta)+\beta}{\sigma(1-\alpha)}} \tag{20}$$

The equilibrium conditions of manufacturing good and agricultural good markets are expressed in (21) and (22), respectively.

$$c_M L_M + \frac{c_A L_A}{\tau_M} + c_H L_H = Q_M \tag{21}$$

$$\frac{a_M L_M}{\tau_A} + a_A L_A + \frac{a_H L_H}{\tau_A} = Q_A \tag{22}$$

Taking account of the relations in (17) and (18), the ratio of shipment values between the manufacturing and agricultural sectors in equilibrium is expressed as

$$z = \frac{p_M Q_M}{p_A Q_A} = \frac{\psi}{\varphi} \tag{23}$$

It is noted that the shipment value ratio will not depend on other endogenous values, but is completely determined solely by the given parameters.

The labor market:

The equilibrium condition of the low-skill labor market in the urban district is represented in the form

$$D_{Up} \overline{l}_M = L_M$$

and the equilibrium wage rate is determined as

$$w_M = \alpha p_M G_M L_M^{-(1-\alpha)} \left(x n^{1/\sigma} \right)^{\beta} D_{Up}^{1-\alpha-\beta} = \frac{\alpha p_M Q_M}{L_M} \tag{24}$$

Since the total wage payment in the intermediate good industry is equal to the total sales to the manufacturing industry, the following relation holds as well.

$$w_H = \frac{\beta p_M Q_M}{L_H} \tag{25}$$

Similarly to (24), the equilibrium wage rate of low-skill labor in the rural district is represented as

$$w_A = \gamma G_A D_A^{1-\gamma} L_A^{-(1-\gamma)} p_A = \frac{\gamma p_A Q_A}{L_A} \tag{26}$$

The land market:

As described above, the regional government will strategically supply land area for each designated use, i.e., D_{Up}, D_{Uh}, D_{Ap} and D_{Ah} in (1). Thus, it is assumed that the land market is set up for each use where each supply of land is given by the government. The equilibrium land rent in each market is thus determined as follows. The urban residence equilibrium condition is represented in the form

$$h_M L_M + h_H L_H = D_{Uh}$$

and the equilibrium residential land rent in the urban district is calculated as

$$r_{Uh} = \left(\frac{\alpha+\beta}{\alpha}\right)\left(1-\psi-\varphi\right)(1-t) w_M \frac{L_M}{D_{Uh}} \tag{27}$$

From (17), per capita residential lot size is:

$$\begin{aligned} h_m &= \left(\frac{\alpha}{\alpha+\beta}\right)\frac{D_{Uh}}{L_M} \\ h_h &= \left(\frac{\beta}{\alpha+\beta}\right)\frac{D_{Uh}}{L_H} \end{aligned} \tag{28}$$

Similarly, the equilibrium land rent in the rural residence market is calculated as

$$r_{Ah} = \left(1-\psi-\varphi\right)(1-t) w_A \frac{L_A}{D_{Ah}} \tag{29}$$

The equilibrium land rent for urban industry use is:

$$r_{Up} = \left(1-\alpha-\beta\right)\frac{p_M Q_M}{D_{Up}} \tag{30}$$

and that for rural industry use is:

$$r_{Ap} = (1-\gamma)\frac{p_A Q_A}{D_{Ap}} \tag{31}$$

Fiscal balance:

The regional government will decide on investment to four kinds of social capital stock (G_M, G_A, I_M and I_A). For simplicity, no depreciation of each stock is assumed, and the government is supposed to finance the investment by long-term loans from foreign countries and to currently pay the interest cost. Source of revenue for this government expenditure are income taxation and land rental revenue, and the government is supposed to keep the balance between revenue and expenditure. It thus holds that

$$T + TR = \overline{r}\left(G_M + G_A + I_M + I_A\right) \tag{32}$$

in which T = total income taxation, TR = total land rent revenue, and $\overline{r}$ = interest rate.

Equilibrium location:

In equilibrium, all the low-skill labor households attain the same utility level regardless of their residential location, since they are perfectly mobile between the two districts. Putting it another way, population distribution of L low-skill labor is determined such that the utility is equalized between the urban and rural districts. The attained utility level in each district is represented as:

$$V_M = \alpha\psi^{\psi}\varphi^{\varphi}(1-t)^{\psi+\varphi}\hat{I}_M\left(\frac{1}{\alpha+\beta}\right)^{1-\psi-\varphi}(z\tau_A)^{\varphi}\left(\frac{Q_M^{\psi}Q_A^{\varphi}D_{Uh}^{1-\psi-\varphi}}{L_M}\right) \tag{33}$$

$$V_A = \gamma^{\psi+\varphi}\psi^{\psi}\varphi^{\varphi}\left(\frac{\tau_M}{z}\right)^{\psi}(1-t)^{\psi+\varphi}\hat{I}_A\left(\frac{Q_M^{\psi}Q_A^{\varphi}D_{Ah}^{1-\psi-\varphi}}{L_A}\right) \tag{34}$$

At equilibrium, it must be true that $V_M = V_A$.

3. Analysis of market equilibrium

The exogenous variables (including policy variables) in the system modeled in the previous section are: high-skill labor population, L_H, total low-skill population, L, total land area in a region, D, and its four divisions (D_{Up}, D_{Uh}, D_{Ap} and D_{Ah}), and four kinds of social capital stock (G_M, G_A, I_M and I_A). Important parameters in the system are transport costs, τ_M and τ_A and interest rate, $\bar{r}$.

The endogenous variables determined as equilibrium solutions in the system are the distribution of low-skill labor population between the two districts, L_M and L_A, total output of manufacturing goods, Q_M, total output of agricultural product, Q_A, number of firms in the intermediate good industry, n, output of each type of intermediate goods, x, three different wage rates (w_H, w_M and w_A), three products' prices (p_M, p_s and p_A), four land rents (r_{Up}, r_{Uh}, r_{Ap} and r_{Ah}), income tax rate, t, and utility level of low-skill labor and high-skill labor, $\bar{V}$ and V_H. The price of manufacturing good, p_M, is treated as numeraire in the subsequent analysis. Among the endogenous variables, x and n are derived directly given the parameters in (6) and (7). The properties of some important endogenous variables will be examined subsequently.

3.1. Urbanization rate

The urbanization rate, defined as the ratio of urban population to total population in a region, is expressed in the form

$$\theta = \frac{L_M + L_H}{L + L_H} = \frac{f + f_H}{1 + f_H} \tag{35}$$

where $f = L_M/L$ and $f_H = L_H/L$.

The equilibrium solution of f is obtained as

$$f = \frac{L_M}{L} = \frac{1}{1 + \frac{\alpha+\beta}{\alpha}\left(\frac{\psi\gamma}{\varphi(\alpha+\beta)}\right)^{\psi+\varphi} \frac{\tau_M^{\psi}}{\tau_A^{\varphi}} \frac{\hat{I}_A}{\hat{I}_M} \left(\frac{D_{Ah}}{D_{Uh}}\right)^{1-\psi-\varphi}} \tag{36}$$

The policy variables affecting urbanization rate are the ratio of residential land area between rural and urban districts, D_{Ah}/D_{Uh}, and the ratio of public stock for living between the two districts, I_A/I_M ; f is a decreasing function of both of them, as intuitively expected. We note that the ratio of industry-related infrastructures, G_A/G_M, dose not affect urbanization rate. This is because the ratio of shipment value between two districts, z, dose not depend on infrastructure level (as (23) indicates) and, accordingly, neither G_M nor G_A appear in (36). This property stems from the constant expenditure ratio for each good due to the Cobb-Douglous type utility function.

Concerning transport cost effect, an increased in τ_M (i.e., a decrease in the transport cost of manufacturing good) will lower f, and thus lower the urbanization rate. This is because manufacturing good can be purchased at a lower price even in the rural district, and therefore many people are induced to reside there. This result is contrasted with the observation in the ordinary NEG mode of τ_A=1, where increased τ_M leads to concentration of population in a particular region (regarded as the urban district).

On the other hand, increased τ_A (i.e., lower transport cost of agricultural product) will promote urbanization since agricultural product is available at a lower price in the urban district. In summary, the labor force tends to be shifted from sectors associated with relatively lowered transport cost to those associated with relatively elevated transport cost.

3.2. Income tax rate

Using (17), (18), (24), (25), (26), (27), (29), (30) and (31), the equilibrium income tax rate is expressed as

$$t = \frac{\Gamma - \Lambda - (1 - \psi - \varphi)}{(\psi + \varphi)} \tag{37}$$

where

$$\Gamma = \frac{\overline{r}\left(G_M + G_A + I_M + I_A\right)}{p_M Q_M \left(\alpha + \beta + \dfrac{\gamma}{z}\right)}$$

$$\Lambda = \frac{\left(1-\alpha-\beta\right)+\dfrac{\left(1-\gamma\right)}{z}}{\left(\alpha+\beta+\dfrac{\gamma}{z}\right)}$$

Γ denote the ratio of government expenditure to total wage income in a region, and Λ the ratio of regional output distributed to land and labor factors. The third term in the numerator in (37) indicates the ratio of housing expenditure in a household's total budget.

3.3. Total manufacturing output

Incorporation of (7) though (9) into (11) gives the following relation.

$$\begin{aligned} Q_M &= G_M \left(\frac{(1-\sigma)^{\frac{1}{\sigma}}\sigma}{a^{\frac{1}{\sigma}}b} \right)^{\beta} L_M^{\alpha} L_H^{\frac{\beta}{\sigma}} D_{Up}^{1-\alpha-\beta} \\ &= G_M \left(\frac{(1-\sigma)^{\frac{1}{\sigma}}\sigma}{a^{\frac{1}{\sigma}}b} \right)^{\beta} f^{\alpha} L^{\alpha} L_H^{\frac{\beta}{\sigma}} D_{Up}^{1-\alpha-\beta} \end{aligned} \tag{38}$$

An interpretation of equation (38) is that manufacturing output is the outcome of cooperation of the three primary factors, namely low-skill labor, high-skill labor and land for industrial use, although the operation of high-skill labor is embodied in intermediate good. Total output of manufacturing good shows increasing return-to-scale with respect to these three factors, since

$$\alpha + \frac{\beta}{\sigma} + 1 - \alpha - \beta = 1 + \beta\left(\frac{1-\sigma}{\sigma}\right) > 1$$

In other words, the urban sector enjoys a scale economy due to the benefit from employment of a variety of intermediate goods (i.e., σ<1). Taking the logarithm of both side of (38) and differentiating it with respect to σ, the following is derived, so as to show the effect of size of σ on the manufacturing output:

$$\frac{d\ln Q_M}{d\sigma} = \frac{\beta}{\sigma^2}\left[-\frac{\sigma^2}{(1-\sigma)} - \ln\frac{(1-\sigma)L_H}{a} \right]$$

Taking account of the fact that $n \geq 1$ in (7), it is concluded that $dQ/d\sigma<0$, that is an increase in the profit from variety (i.e., a decrease in σ) works to increase urban industrial output.

3.4. Utility level

Taking advantage of (33) and (34), the equilibrium utility level of low-skill labor is expressed in the form

$$\bar{V} = E\left(1-t\right)^{\psi+\varphi} f^{\alpha\psi-1}\left(1-f\right)^{\varphi\gamma} G_M^{\psi} G_A^{\varphi} D_{Up}^{\psi(1-\alpha-\beta)} D_{Ap}^{\varphi(1-\gamma)} D_{Uh}^{1-\psi-\varphi} L^{\alpha\psi+\varphi\gamma-1} L_H^{\frac{\beta\psi}{\sigma}} \qquad (39)$$

where

$$E = \alpha\psi^{\psi}\varphi^{\varphi}\left(z\tau_A\right)^{\varphi}\left(\frac{1}{\alpha+\beta}\right)^{1-\psi-\varphi}\left[\left(\frac{1-\sigma}{\alpha}\right)^{\frac{1-\sigma}{\sigma}}\frac{\sigma}{b}\right]^{\beta\psi}$$

In (39), f dose not depend on L, as discussed above, but t is affected by L. It thus follows that

$$\frac{d\bar{V}}{dL} = \left[\frac{\alpha\Gamma}{1-t} + \left(\alpha\psi + \gamma\varphi - 1\right)\right]\frac{\bar{V}}{L} \qquad (40)$$

The sign of (40) is indeterminate since $\alpha\psi+\gamma\varphi-1<0$[3] while $\alpha\Gamma/(1\text{-}t)>0$. From (37), t decreases with Q_M. An increase in L will increase Q_M, thus resulting in $dt/dL<0$. This will contribute to increasing equilibrium utility level. On the other hand, increased population will reduce per capita residential lot size and thereby lower the utility level. Therefore, the net effect of increased low-skill population on the utility level depends on the relative strength of these two opposing effects[4].

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[3] This is proved in the following way. If $\alpha>\gamma$, then it follow that $\alpha\psi+\gamma\psi<\alpha(\psi+\varphi)<1$. In a similar manner, we also reach the same conclusion where $\alpha<\gamma$.

[4] It is natural that the utility level of high-skill labor, V_H, is higher than that of low-skill labor, , in equilibrium, since every resident has an identical utility function. The condition to ensure this difference is that, and is met when the population of high-skill labor, L_H, is considerably small relative to that of low-skill labor, L.

4. Optimal land use policy

As observed above, equilibrium solutions of the system depend on the allocation of land area among four alternative uses, namely D_{Up}, D_{Uh}, D_{Ap} and D_{Ah}. In this context, land use policy, thus has a critically important role in the system. It is hypothesized that the regional government will determine a specific land use plan so as to maximize the (equilibrium) utility level of low-skill labor[5]. That is, the government will determine D_{Up}, D_{Uh}, D_{Ap} and D_{Ah} so as to maximize (39) subject to (36), (37), (38) and land area constraint (1). At optimum, it holds that

$$\frac{D_{Up}}{D_{Ap}} = \frac{(1-\alpha-\beta)(\psi+\frac{\Gamma}{1-t})}{\varphi(1-\gamma)} \tag{41}$$

$$\frac{D_{Uh}+D_{Ah}}{D_{Ap}} = \frac{(1-\psi-\varphi)}{\varphi(1-\gamma)} \tag{42}$$

Therefore the ratio between residential land area and industrial land area in the region is determined as

$$\frac{D_{Uh}+D_{Ah}}{D_{Up}+D_{Ap}} = \frac{1-\psi-\varphi}{\varphi(1-\gamma)+(1-\alpha-\beta)\left(\psi+\frac{\Gamma}{1-t}\right)} \tag{43}$$

The effects of parameter changes in (41) and (42) are obvious: a decrease in α and β and increase in ψ will work to relatively expand the industrial land area in the urban district while a decrease in γ and increase in ψ will work to relatively expand the agricultural land area.

In general, increased γ elevates the ratio of residential land area. A larger share of public investment in regional total wage income tends to increase industrial land use and, in particular, the land area for urban industry.

[5] This optimization policy is justified; in particular, where the population of high-skill labor, L_H, is considerably small relative to that of low-skill labor, L and high-skill labor is relatively well off. Increasing the welfare of low-skill workers will contribute to stabilizing the regional society.

5. Comparative static analysis with numerical simulation

Although conspicuous properties of some of the important endogenous variables could be investigated above, it is difficult to perform comparative static analytically, such as for the effects of environmental change (i.e., changes in exogenous variables and parameters). Therefore, numerical simulation was carried out to evaluate the effects of changes in some important exogenous variables or parameters. In the simulation analysis, focus is placed, in particular, on the urbanization rate and utility levels of residents. (owing to limited space, the results only for the effects of a change in transportation cost is explained below).

The simulation sets the basic value of each parameter as in the Table 1

Table 1. Basic value of parameters in our model

Parameter	Basic Value
α	0.33
β	0.33
γ	0.50
ψ	0.33
φ	0.33
τ_M	0.20, 0.50, 1.00
τ_A	0.20, 0.50, 1.00
σ	0.50
a	0.01
b	1E-3
r	0.10
L_H	0.10
L	1.00
D	1.00

5.1. Decease in transportation cost of manufacturing good (increase in τ_M)

Simulation was carried out for three alternative values of transportation cost of agricultural product substituted for manufacturing good to consumers (i.e., τ_A=0.20, 0.50, and 1.00). Common results are summarized as follows.

1-1. Urbanization rate increases as τ_M increases (namely the transport cost of manufacturing good decreases) as shown in Figure 1. This is the case even where no transport cost occurs for agricultural product, namely τ_A=1.00. This result is similar to that of the Krugman-type NEG model where lowered transport cost of manufacturing good promotes concentration of population to a center, but is contrary to the result of Fujita and Krugman (1995).

1-2. The ratio of urban industrial land (D_{Up}/D) slightly decreases with τ_M while urban residential land ratio (D_{Uh}/D) increases greatly. However, in the rural market the land use ratio for production increases and that for housing decreases with τ_M.

1-3. The wage rate of manufacturing workers slightly decreases while that of agricultural workers slightly increases. High-skill labor's wage rate increases as output of manufacturing industry increases.

1-4. Reflecting the tendency of 1-2, the rent increases for industrial land and decreases for residential land in the urban district. On the other hand, in the rural district, the rent is lowered for industrial use but elevated for residential use.

1-5. As Figure 2 shows, the utility of both low-skill and high-skill workers increase as τ_M increases. This is because residential land rent is lowered and the price of agricultural product is lowered although the wage rate is lowered in urban district.

Equation (36) shows some determinants of the urbanization rate. Among these variables $\tau_M^{\psi} \big/ \tau_A^{\varphi}$ and $(D_{Ah}/D_{Uh})^{1-\psi-\varphi}$ vary when τ_M is changed. A difference from the Krugman-type NEG model is that variables of land use affect the urbanization rate. In (36), both τ_M/τ_A and D_{Ah}/D_{Uh} operate to lower the urbanization rate. However, in the simulation in Figure 1, the equilibrium urbanization rate increases, although not dramatically, as τ_M is increased.

Figure 3 helps to solve this "seeming" contradiction. In the simulation, τ_M/τ_A monotonously increases, but Figure 3 shows that the government's land use policy changes so that D_{Ah}/D_{Uh} monotonously decreases. Thus, the trend of equilibrium urbanization rate in Figure1 implies that the effect of change in land use plan prevails over that of the change in transport cost. Figure 1 and Figure 3 suggest that the difference between the two opposing effects is larger when the transport cost of agricultural product is higher (i.e., smaller τ_A). This result is intuitively acceptable since the production of manufacturing good becomes more favorable when τ_A is smaller.

It is expected, in general, that a decrease in the transport cost of agricultural product will produce results contrasting to those for a decrease in the transport cost of manufacturing good. As expected, in the simulation of increasing τ_A, the ratio of land use for agricultural production is reduced and so is the urbanization rate. Urbanization is higher where the transport cost of manufacturing good is lower (i.e., larger τ_M). In addition, the wage rate of a worker in the manufacturing industry increases while that of high-skill labor decreases. The only unique effect is that the utility level of high-skill labor monotonously decreases. This is because the residential land rent in the urban district markedly increases as the transport cost of agricultural product decreases.

6. Comparison with Fujita and Krugman (1995)

Our model is quite close to that of Fujita and Krugman (1995) (hereafter abbreviated as F-K) in that an isolated region is investigated. However, a marked difference lies in the treatment of the urban district. In our model, the urban district always exists in contrast to the rural district, and the size of the urban district is determined by urbanization rate. On the other hand, in F-K model, the urban district is not explicitly treated and only when manufacturing firms are agglomerated to one point, that central location can be viewed as an urban district and the share of workers there is interpreted as urbanization rate. This urbanization rate, measured by n^* in the F-K model, and our urbanization rate, θ, are different in that changes in some parameters have different effects on them. For instance, when σ increases (i.e., the advantage of variety becomes smaller), θ increases in our model while n^* decreases in the F-K model. Increased population necessarily promotes urbanization in the F-K model, but an increase in low-skilled labor population lowers the urbanization rate in our model. A decrease in the transport cost of manufacturing good will lower the urbanization rate in the F-K model but it will elevate θ in our model. A decrease in the transport cost of agricultural product lowers the urbanization rate in our model, but possibly heightens it in the F-K model.

Some comparative statics, in particular, of the effect on equilibrium utility level are ambiguous in the F-K model. This is due, as in our model, to the distortion stemming from imperfect competition where the marginal cost pricing-principle dose not hold. In the F-K model, for example, decreased labor productivity in the agricultural sector can rather increase the utility level of residents (particularly when the advantage of variety is small), and increased transport cost will increase the welfare level when the advantage of variety is large.

In the F-K model, an increase in the number of workers has a positive effect on people’s welfare by increasing variety through increased urban population and, at the same time, has a negative effect by increasing spatial distance through increased rural population. Reflecting these opposing effects, the relationship of utility level of people has an inverted-U shape with respect to population, and thus an optimal population size, $\hat{N}$ exists. It holds that $d\hat{N}/d\sigma < 0$ in the F-K model, since an increase in σ reduces the benefit from variety, and thereby operates to reduce the optimal population size. On the contrary, it holds that $d\hat{N}/d\sigma > 0$ in our model. Needless to say, such disparity is due to differences in model structure. In our model, the government’s behavior is explicitly considered, where the government strategically decides on land use for industry and residence while keeping the balanced budget. Under these circumstances, an increase in σ operates to decrease Q_M, which can be interpreted as delaying the appearance of the effect of lowered tax rate through increased population. On the other hand, in the F-K model, an increase in σ directly reduces the positive effect of variety through increased population, and therefore decreases the optimal population.

7. Concluding remarks

This paper set out to analyze the urbanization process, incorporating land service explicitly in both industrial and residential sectors within the framework of a NEG model and making the government's land use policy endogenous. In particular, bearing in mind the recent urbanization development in Chinese economic society, the model was constructed such that the role of government in managing land use allocation was explicitly introduced and the policy effects of public investment, financed though income taxation and land rental can be evaluated.

In the urban district, intermediated goods are produced by employing only high-skill labor and manufacturing good is produced with intermediate goods, land and low-skilled labor. Each firm in the intermediate goods industry has increasing return-to-scale technology and faces monopolistic competition. Manufacturing industry "aggregates" various intermediate goods as inputs into production and benefit form their variety. In the rural district, Agricultural good is produced by employing land and low-skill labor. Transporting manufacturing good and agricultural product between urban and rural districts incurs additional costs. People with low-skill are mobile between two districts so as to attain equal utility in equilibrium while people with high skill are hypothesized to reside only in the urban district. An individual needs residential land for housing in his (or her) district. The government expends revenue from taxation and land rent on investment to both industry-related and amenity-augmenting public capital in each district (although they are exogenous variables in the model)

The main results of the theoretical analysis are as follows. The first, urbanization rate, measured by urban population share, depends of the ratio of transport costs between agricultural and manufacturing goods, and on the residential land ratio between the urban and rural districts, increasing with these ratios. Secondly, under fixed land area in a region, increased population of low-skill labor works to lower their utility level in equilibrium, on the other hand, and to heighten the utility level through lowering the income tax rate in equilibrium on the other. In this sense, an optimal population size is expected to exist. Thirdly, where government plans the land use in a region so as to maximize the utility level of low-skill workers, a decrease in the value of α and β and an increase in ψ operates to expand the land area for urban production; a decrease in γ and increase in φ work to expand the land area for rural production. Increased γ expands the land area for residence in a region.

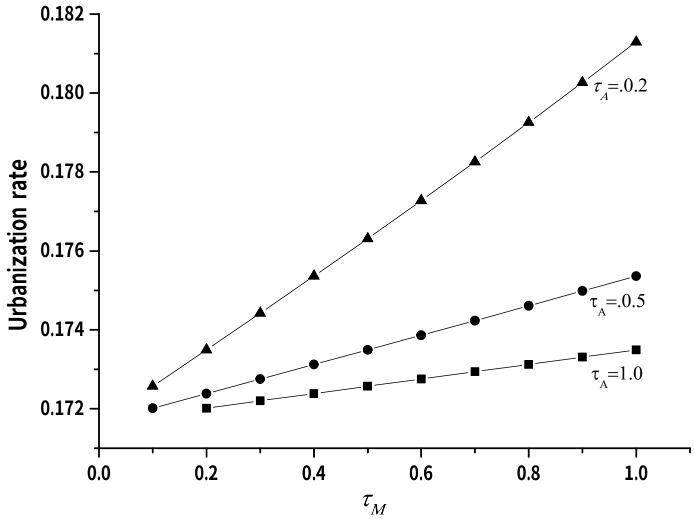

Figure 1. Transport cost of manufacturing good and urbanization rate

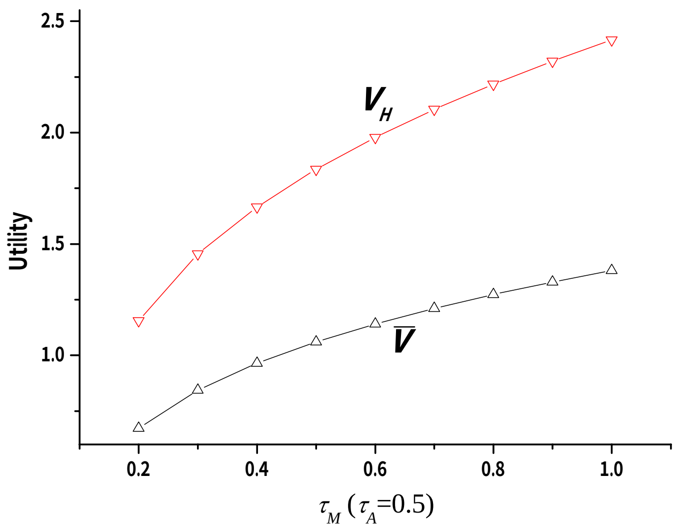

Figure 2. Effect of transport cost of manufacturing good on the utility of high- and low-skill labor

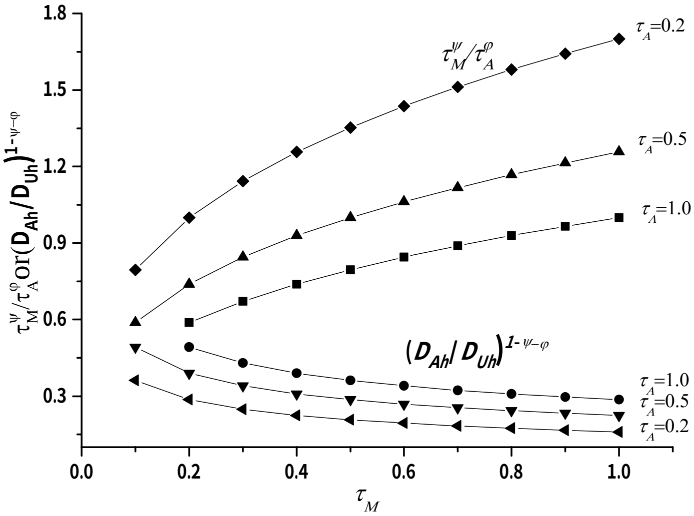

Figure 3. Two primary factors determining the urbanization rate

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